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(54) Counter-balanced well-head apparatus

(57) Well-head apparatus (10) comprises a support structure (11) surmounting a well-head (12). A pump rod (14) extends vertically from the well-head (12) and is coupled to a down-hole pump, the upper end of rod (14) being connected to the piston of a piston and cylinder unit (15) the cylinder of which is secured to the structure (11). Motive fluid is applied to unit (15) by a source (18) via a control device (19) so that unit (15) functions as a work-load unit. A counterbalance-load piston-and-cylinder unit (21) may be provided with its piston connected to the piston of unit (15) via a common headstock (23). Unit (21) is supplied with pressurised fluid from supply (22) and provides a substantially constant counterbalance force on rod (14).

If required a plurality of well-head units may be operated by a common hydraulic supply.

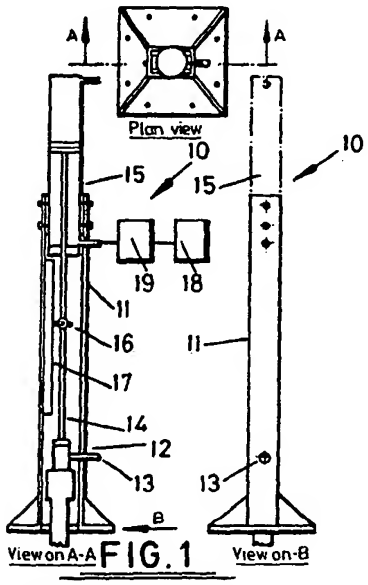

FIG. 1

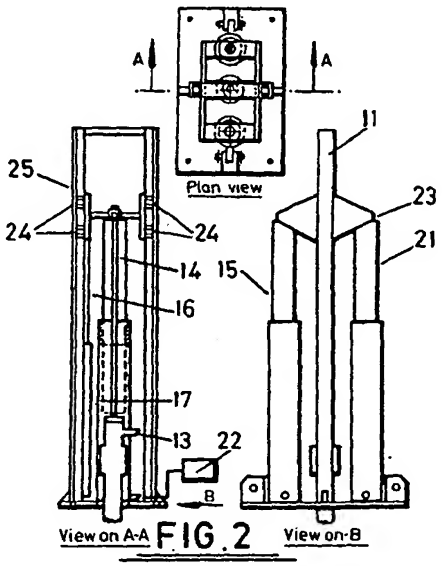

FIG. 2

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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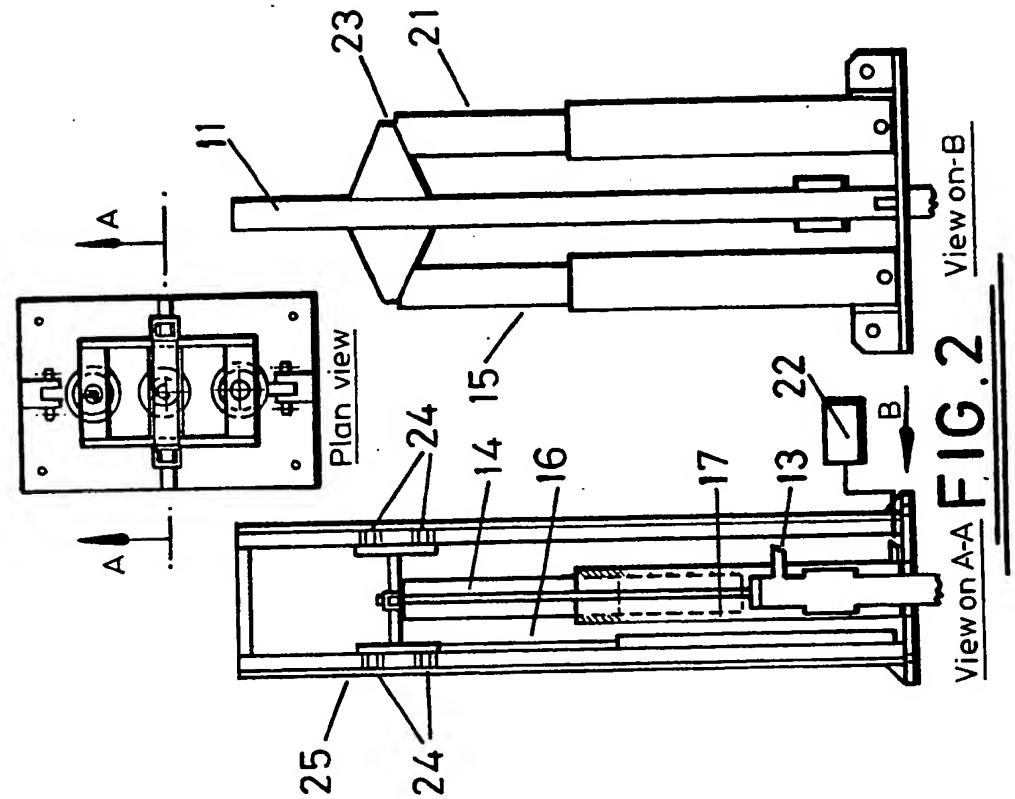

FIG. 2

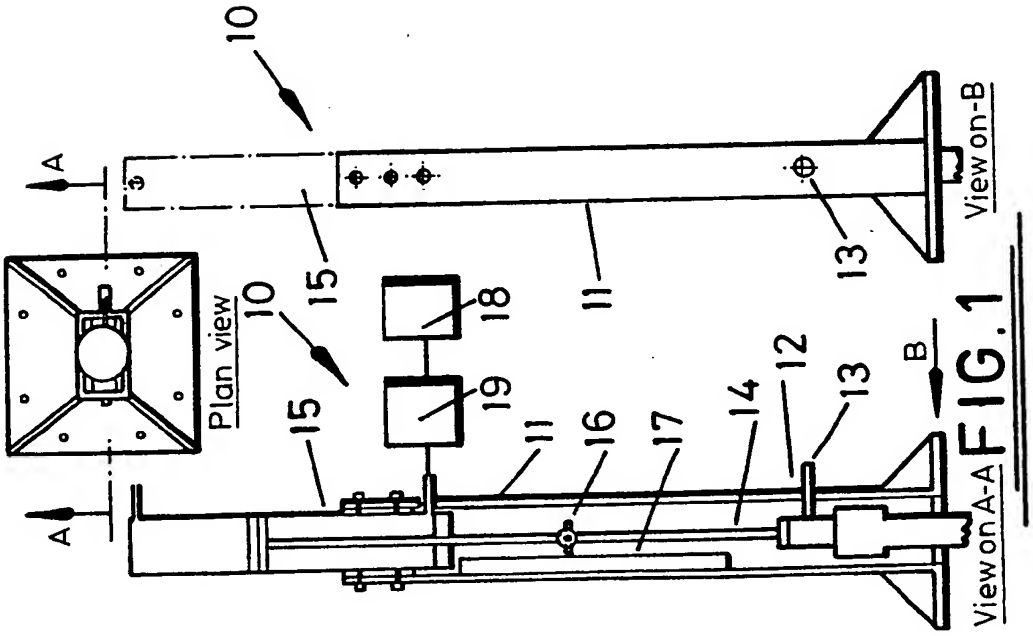

FIG. 1

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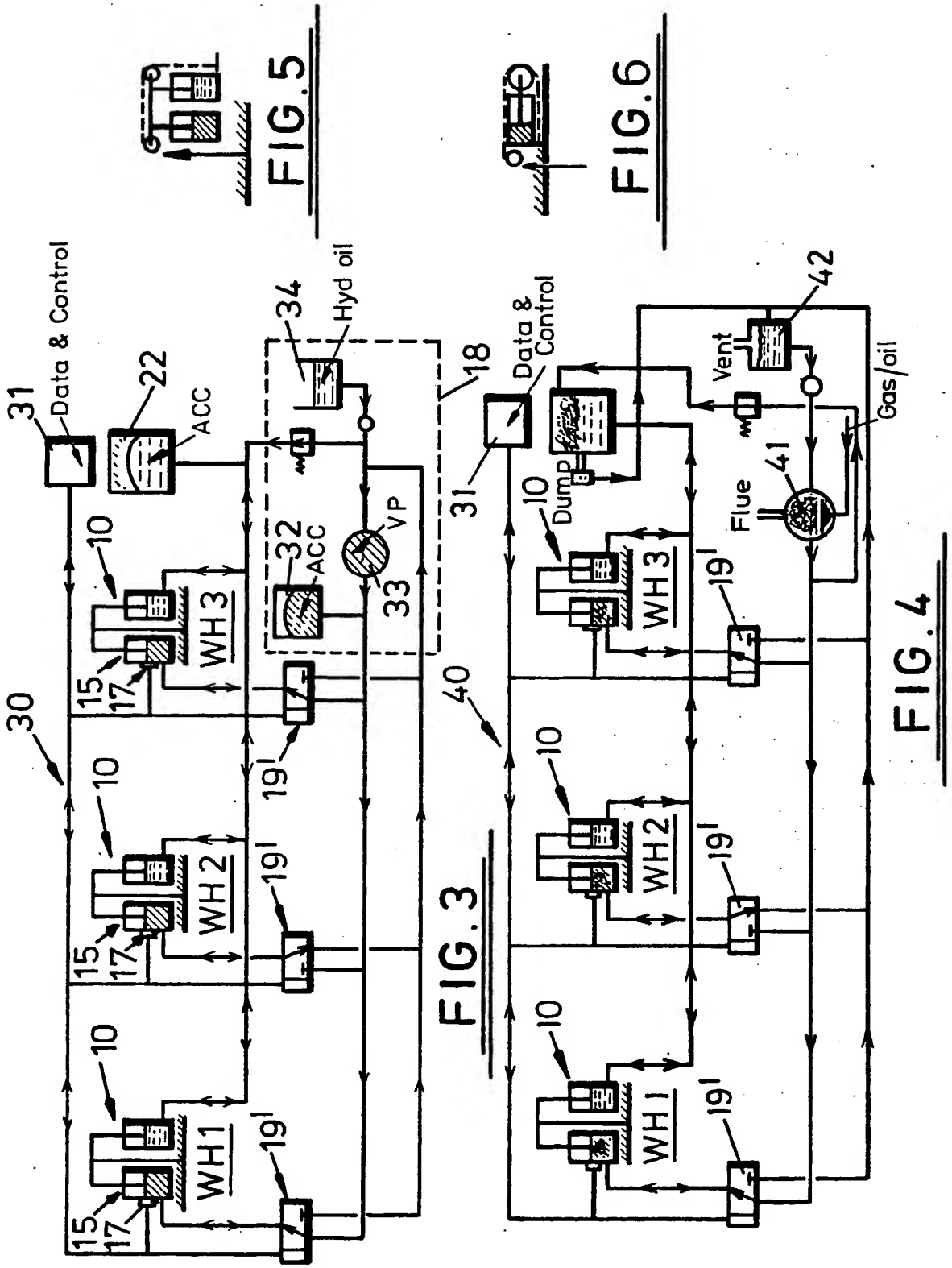

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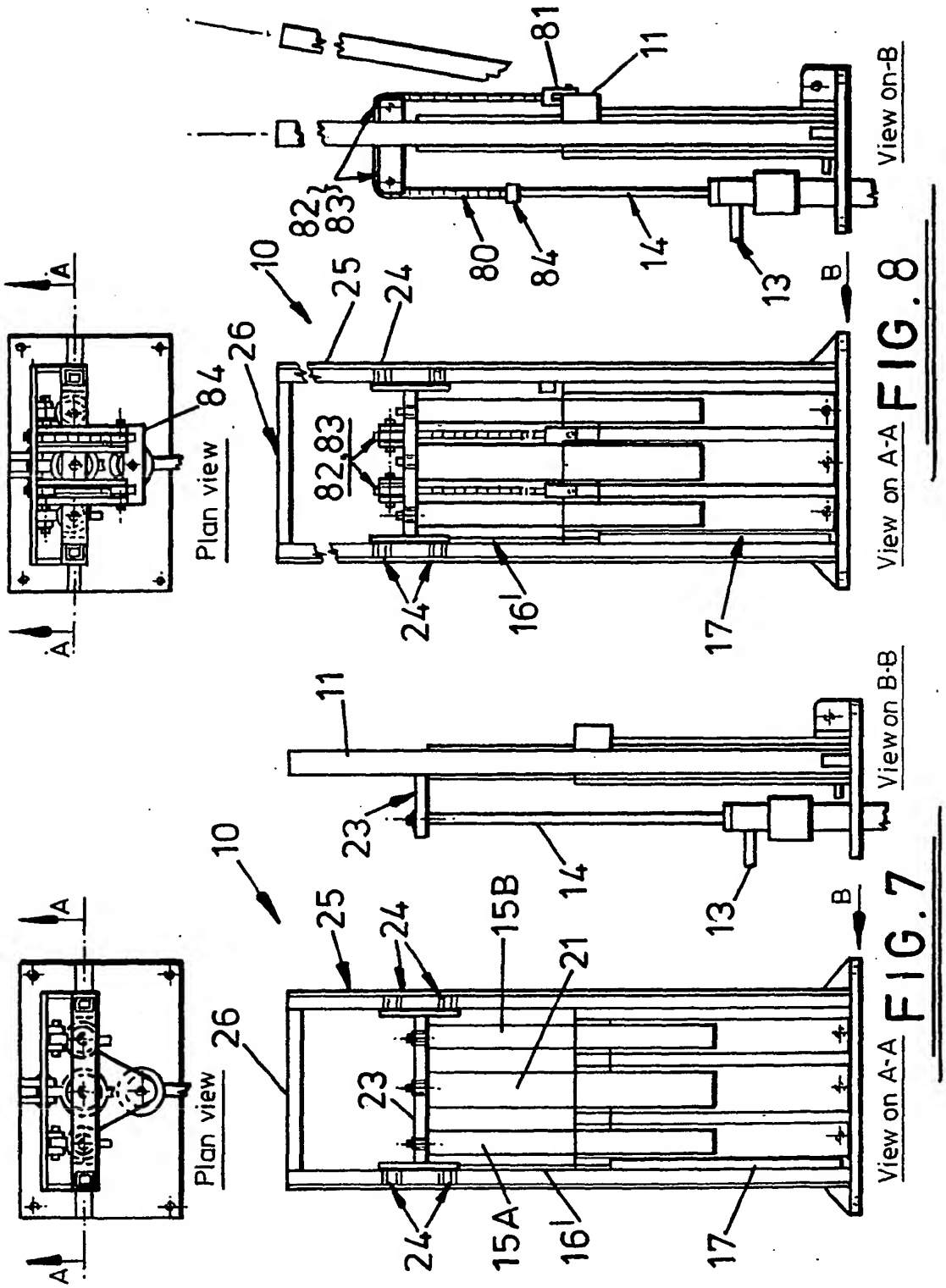

FIG. 7

FIG. 8

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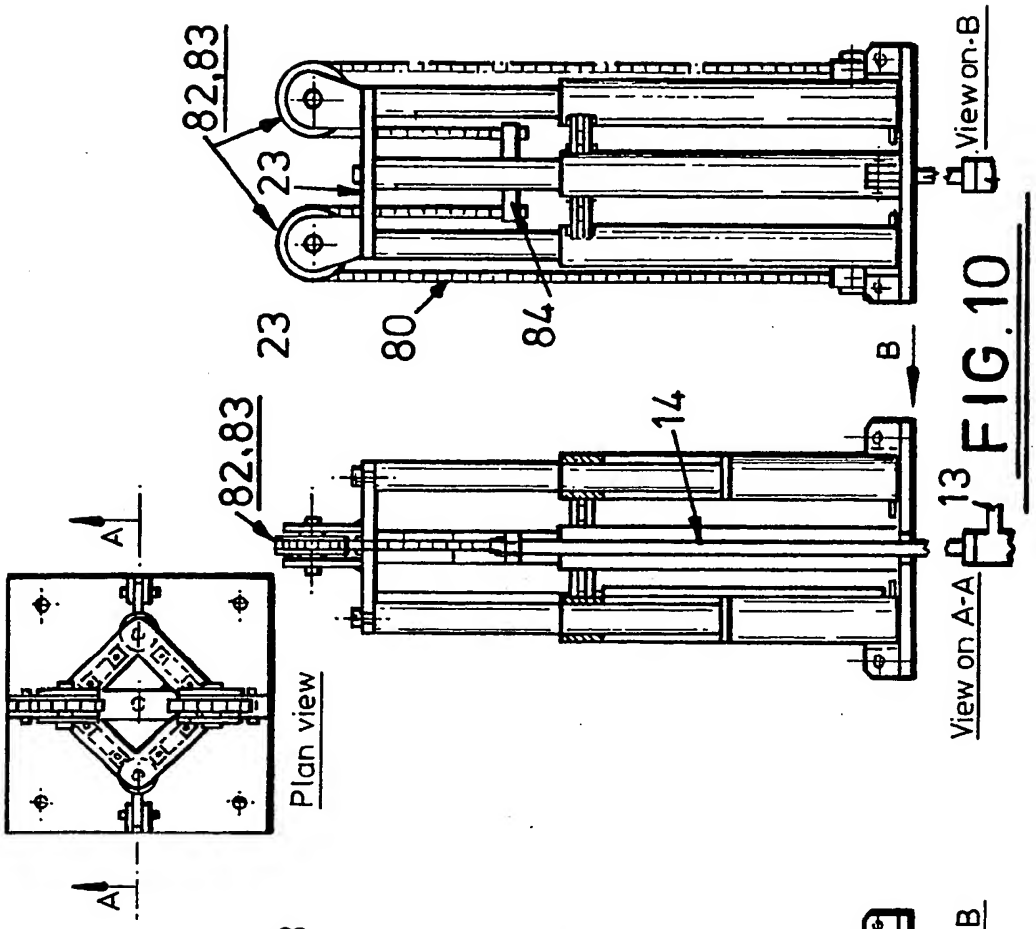

FIG. 10

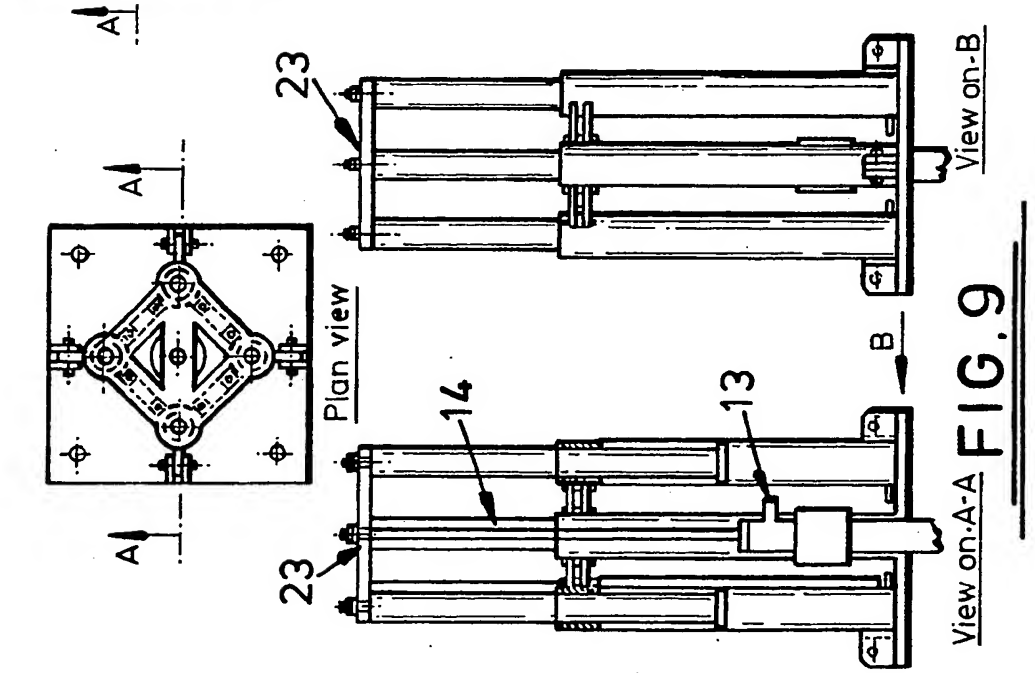

FIG. 9

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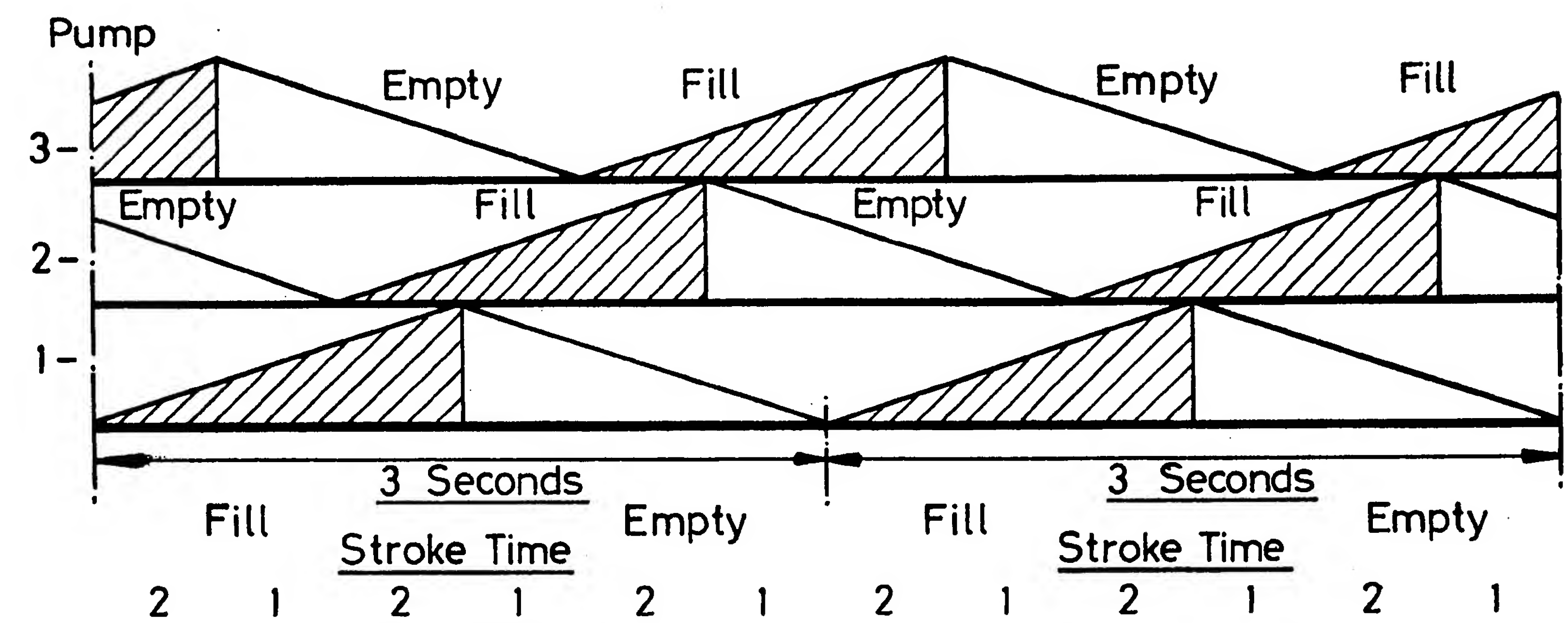

Units of Power

	From Store	To Store	From Store	To Store	From Store	To Store	From Store	To Store	From Store	To Store	From Store	To Store
Acc. H.P.	50	50	50	50	50	50	50	50	50	50	50	50
Direct H.P.	150	100	150	100	150	100	150	100	150	100	150	100

Accumulator Capacity = 0·5 secs at 50 H.P. (16.6% of a cylinder volume)
Installed Horsepower(BHP) = 150 (50/Pump) Unit of Power = 100 H.P.

FIG.11

SPECIFICATION

Well-head apparatus

This invention relates to well-head apparatus for operating a down-hole pump via a pump actuating mechanism extending from the well-head to the pump.

Apparatus of the present invention finds use in connection with pumping of crude oil in both onshore and offshore wells and with pumping of water and slurry from pits or wells.

According to the present invention there is provided well-head apparatus for operating a down-hole pump via a pump actuating mechanism extending from the well head to the pump, said apparatus comprising a work-load piston and cylinder unit, mechanical means interconnecting the piston of said work load unit with the pump actuating mechanism, and motive fluid supply means coupled to said work load unit via control means and operable selectively to move the piston relative to the cylinder of said work-load unit so as selectively to impose a work-load force on the pump actuating mechanism.

By virtue of the present invention the time proven lift pump may be retained within the well and actuated at the well head by means of a work-load piston and cylinder unit which may be relatively small and inconspicuous whilst singulary efficient. The work-load unit may be hydraulically operated or steam operated and may be mechanically connected to the pump actuating mechanism either directly or indirectly, for example by chain and pulley whereby a mechanical advantage is provided and/or the line of action of the work-load force imposed on the pump-actuating mechanism differs from that generated by the work-load unit.

Conveniently the well-head apparatus further comprises a counterbalance-load piston and cylinder unit the piston of which is mechanically coupled in parallel with the piston of the work-load unit to the pump actuating mechanism, and pressurised fluid supply means is provided for said counterbalance-load unit and arranged to impose a substantially constant counterbalance-load force on the pump actuating mechanism.

Preferably the apparatus further includes displacement monitoring means for monitoring displacement of the pump actuating mechanism and the control means comprises displacement comparator means for comparing pre-set upper and lower displacement levels with monitored displacement levels obtained from said displacement monitoring means, the control means being operable to terminate movement to the work-load piston when the monitored displacement levels equate to the pre-set upper and lower displacement levels respectively.

Preferably also the apparatus further includes displacement rate monitoring means for monitoring displacement rate of said pump actuating mechanism, and said control means comprises displacement-rate comparator means for comparing pre-set displacement rates with monitored displacement rates obtained from said displacement-rate monitoring means, the control means being operable to govern displacement rate of the work-load piston so that it equates to the pre-set displacement rates.

Conveniently the well-head apparatus forms part of an assembly comprising a plurality of similar well-head apparatus arranged for operating respectively down-hole pumps in phased relationship from a common motive fluid supply means, the control means being arranged to establish the phased relationship so that a substantially continuous load is imposed upon the supply means.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 illustrates plan, front and side elevational views of well-head apparatus according to the present invention;

Fig. 2 illustrates a modified form of the Fig. 1 apparatus which incorporates a counterbalance piston and cylinder unit;

Fig. 3 illustrates an assembly incorporating a plurality of the Fig. 2 apparatus;

Fig. 4 is a modification of Fig. 3 assembly;

Figs. 5 and 6 schematically illustrate modified details of the apparatus;

Fig. 7, 8, 9 and 10 illustrate different mechanical arrangements of the apparatus; and

Fig. 11 illustrates a power plot for the Fig. 1 arrangement.

As is shown in Fig. 1 of the drawings well-head apparatus 10 comprises a support structure 11 surmounting a well-head 12 having a laterally-extending outlet 13 for discharge of pumped fluid. A pump rod 14 extends vertically from the well-head 12 and is coupled to a pump (not shown) within the well in conventional manner. The apparatus 10 incorporates a work-load piston and cylinder unit 15 the cylinder of which is secured to the support structure 11 and the piston of which is secured (via a piston rod) to the pump rod 14 at a coupling 16 which functions additionally in combination with a sensor 17 secured to structure 11 as a displacement monitoring means. Motive fluid is applied by source 18 via control means 19 to unit 15 on one side of the piston only, the other being vented, whereby the piston of unit 15 is selectively reciprocated.

The arrangement of Fig. 2 illustrates the apparatus 10 of Fig. 1 in combination with a counterbalance-load piston and cylinder unit 21, the piston of which is connected in parallel with the piston of work-load unit 15 by means of a common headstock 23. Headstock 23 carries guide rollers 24 which run in guides 25 formed in the support structure 11 and the units 15, 21 lie laterally of the pump rod 14 to provide mechanical balance. Guides 25 are interconnected at their top ends by a cross-piece 26 which functions as a travel stop to limit the extent of displacement of rod 14. The counterbalance-load unit 12 is supplied with pressurised fluid from a supply 22 so that a substantially constant counterbalance-load force is imposed on the rod 14. In this arrangement rod 16' connected to headstock 23 operates on a sensor 17

to provide a displacement monitoring means.

Fig. 3 illustrates and assembly 30 formed by three well-head apparatus 10 of the Fig. 2 type connected at respective well-heads and each piston and cylinder unit 15, 21 is hydraulically operated. The units 15 are hydraulically controlled by their respective control means 19 which take the form of an electrically-operated hydraulic valve 19' electrically-connected to an electrical controller 31, each valve 19' being hydraulically connected in parallel to a source 18 of pressurised hydraulic fluid incorporating a pneumatically-loaded accumulator 32, a variable pressure pump 33 and a supply tank 34. The units 21 likewise are connected in parallel to supply 22 which is in the form of a pneumatically-loaded accumulator. Controller 31 is connected to monitoring means 17 in order to receive displacement signals from each apparatus 10 so that phasing of the operation of each apparatus 10 by control of each valve 19' can be effected as will be explained.

Fig. 4 illustrates an assembly 40 similar to assembly 30 of Fig. 3 but differing principally in that the fluid utilised for piston and cylinder units 15, 21 is steam provided by boiler 41 and water source 42.

In the arrangement of apparatus 10 which have been discussed the mechanical connection between piston and cylinder units 15, 21 and pump rod 14 have been direct. Figs. 5 and 6 schematically illustrate indirect mechanical connections through the use of chain and pulley wheels as a result of which mechanical advantage is obtained and/or the line of action of the force generated by the units 15, 21 differs from the work-load force imposed on the pump rod 14 as a consequence of which the orientation of the apparatus 10 can be profiled to suit the environment.

By way of example other configurations of the apparatus 10 are illustrated in Figs. 7, 8, 9 and 10. Thus in Fig. 7 the apparatus is similar to that of Fig. 2 but one of piston and cylinder units 15, 21 is split into two so that there are three pistons and cylinder units in total arranged side by side and the outer two of the three are hydraulically connected in parallel. This arrangement provides a simple method of achieving different hydraulic power levels whilst keeping the piston and cylinder units approximately mechanically matched in size. For example Fig. 7 illustrates unit 15 split into two units 15A, 15B.

Fig. 8 shows apparatus 10 somewhat similar to the Fig. 7 apparatus but with a chain and pulley wheel connection with pump rod 14. In this case chain 80 is connected between a header 84 on pump 14 and an anchor 81 mounted on support structure 11 and is reeved around two pairs of pulley wheels 82, 83 mounted on headstock 23. With this arrangement the support structure 11 can conveniently be angled, for example by 10° or so, to accomodate deviated wells.

In the arrangement of Fig. 9 the apparatus 10 comprises a set of two piston and cylinders forming unit 15 and a further set of two piston and cylinders forming unit 21, the four piston and cylinders being arranged around the well head 12 with four pistons and the pump rod 14 directly connected to a common headstock 23. The Fig. 10 arrangement is generally similar to the Fig. 9 arrangement but is provided with a chain and pulley wheel c nnection to the pump rod 14 in a manner similar to that of Fig. 8.

In operation the apparatus 10 of Fig. 1, which is the simplest form of the apparatus, has its unit 15 sequentially pressurised with fluid from the supply means 18. By way of example, when the supply means 18 incorporates accumulator 32 as illustrated, pump 33 can be arranged to operate with half the brake horsepower required by unit 15, the other half of the required horsepower being provided by accumulator 32 so that when pump rod 14 is elevated the required energy is provided by components 32 and 33 in combination and during the time interval that the pump rod 14, which is relatively massive due to its length, drives the piston of unit 15 downwardly unit 15 recharges accumulator 32 via the pump 33, the upstroke and downstroke time intervals being equal as dictated by control unit 31. The assembly 30 of Fig. 3 which incorporates three sets of the apparatus 10 can be arranged so that during the piston downstroke of one apparatus 10 there is a piston upstroke of at least another apparatus 10 for the purpose of reducing or eliminating the need to have an accumulator 32, this phasing being controlled in time by control unit 31. For example in an assembly which has only two sets of apparatus 10 the piston downstroke of one unit 15 can be arranged to occur exactly over the same time interval as a piston upstroke of the other unit 15 and vice versa in which case accumulator 32 is not required.

In the Fig. 3 case where there are three sets of apparatus 10 it is preferred that during the piston upstroke of a first apparatus 10 there is a piston upstroke of one other apparatus 10 commencing approximately two-thirds through the time interval of the first apparatus 10, whereby providing a power plot as shown in Fig. 11. In this arrangement since there is an odd number of sets of apparatus 10 it is necessary to have accumulator 32 but the capacity thereof can be restricted to about 16—17% of the volume of one unit 15.

It will be appreciated that variable pump 33 is variable in both pressure and flow rate.

CLAIMS

1. Well-head apparatus for operating a down-hole pump via a pump actuating mechanism extending from the well head to the pump, said apparatus comprising a work-load piston and cylinder unit, mechanical means interconnecting the piston of said work load unit with the pump actuating mechanism, and motive fluid supply means coupl d to said work load unit via control means and operable selectively to move th piston relative to the cylinder of said work-load unit so as sel ctively to impose a work-load force on the pump actuating mechanism.

2. Apparatus as claimed in claim 1, wherein the well-head apparatus further comprises a counterbalance-load piston and cylinder unit th

piston of which is mechanically coupled in parallel with the piston of the work-load unit to the pump actuating mechanism, and pressurised fluid supply means is provided for said counterbalance-load unit and arranged to impose a substantially constant counterbalance-load force on the pump actuating mechanism.

3. Apparatus as claimed in either preceding claim, wherein the apparatus further includes displacement monitoring means for monitoring displacement of the pump actuating mechanism and the control means comprises displacement. comparator means for comparing pre-set upper and lower displacement levels with monitored displacement levels obtained from said displacement monitoring means, the control means being operable to terminate movement of the work-load piston when the monitored displacement levels equate to the pre-set upper and lower displacement levels respectively.

4. Apparatus as claimed in any preceding claim, wherein the apparatus further includes displacement rate monitoring means for monitoring displacement rate of said pump actuating mechanism, and said control means comprises displacement-rate comparator means for comparing pre-set displacement rates with monitored displacement rates obtained from said displacement-rate monitoring means, the control means being operable to govern displacement rate of the work-load piston so that it equates to the pre-set displac ment rat s.

5. Apparatus as claimed in any preceding claim, wherein the well-head apparatus forms part of an assembly comprising a plurality of similar well-head apparatus arranged for operating respective down-hole pumps in phased relationship from a common motive fluid supply means, the control means being arranged to establish the phased relationship so that a substantially continuous load is imposed upon the supply means.

6. Apparatus as claimed in any preceding claim, wherein each piston and cylinder unit is directly mechanically connected to the pump actuating mechanism.

7. Apparatus as claimed in any one of claims 1—5, wherein each piston and cylinder unit connected to the pump actuating mechamism via a pulley and chain arrangement.

8. Apparatus as claimed in claim 7, wherein said pulley and chain arrangement is arranged so that the line of action of the work-load force imposed on the pump actuating mechanism differs from that generated by the work-load unit.

9. Apparatus as claimed in claim 1 and substantially as hereinbefore described with reference to any one of the embodiments illustrated in the accompanying drawings.

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